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DETERMINATION OF TURNAROUND TIME AND ITS RELATION TO UTILIZATION OF FREIGHT CARS IN CHINA

/Comment: This report gives the pertinent information from an article by Liu Chia-t'ao on the relationship of turnaround time to the utilization of freight cars. To avoid the use of cumbersome terms and expressions in the formulas, certain symbols and abbreviations have been employed. A glossary of these symbols and abbreviations follows.

GLOSSARY OF SYMBOLS AND ABBREVIATIONS

TRT	Turnaround Time. As commonly accepted in the US.
TRD	Turnaround Distance. The average distance traveled per loaded car in one turnaround time period.
COP	Total Number of Cars in Operation.
DWL	Daily Work Load. The daily average number of loaded cars handled. This number includes those loaded within the bureau's territory and those entering from the adjacent territory of another bureau.
CLD	Number of Cars Unloaded. Average per day.
CUN	Number of Cars Unloaded. Average per day.
NLC	Number of Loaded Cars.
NEC	Number of Empty Cars.
DLC	Distance Traveled by Loaded Cars.
DEC	Distance Traveled by Empty Cars.

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TRVT Travel Time. Elapsed time during which train is in transit, including incidental stops at way stations for water or fuel, but not including time spent switching in station yards or at terminals.

TRVS Travel Speed. Distance traveled divided by travel time.

TKM Total Kilometrage Of All Cars, Loaded and Unloaded; Daily Average.

SWD Average Switching Distance. This is not the distance that cars are shunted around in switching yards. It is rather a figure that indicates the frequency of switching, or the number of times that switching takes place. It is found by dividing the total distance (TKM) by the number of cars switched.

NCSW Number of Cars Switched. Sometimes indicated as the number of cars handled in switching stations. This figure would exclude the cars in a train which passed through a junction point without breakup or rearrangement of the cars in the train.

SWT Average Switching Time. This refers to the average time spent per car in stations where switching actually takes place. It includes the whole time from moment of arrival until moment of departure. It bears no relation whatever to SWD.

STPT Average Stopping Time. The stopping time as used in this article consists of the interval required for loading and unloading operations, each considered as a separate operation. This is construed as including the whole time, from arrival until departure, that a car spends in a terminal where it is loaded or unloaded.

PCE Percentage of Empty Cars. This figure expresses the ratio between the number of empty cars and the number of all cars handled.

WR Work Rate. This term is used to express the ratio between the number of cars loaded plus the number of cars unloaded, and the total number of cars handled (DWL).

The article by Liu follows.]

TURNAROUND TIME AND ITS RELATIONSHIP TO FREIGHT CAR UTILIZATION

Turnaround time is the basic yardstick by which to measure the use being made of the rolling stock. The statistics needed for computing turnaround time bear a close relationship to transportation plans. Without a good statistical system and accurate data, it is impossible to produce suitable transportation plans. Because of this, no matter whether one is investigating the efficient use of rolling stock or aiming to provide suitable transportation plans, the accurate calculation of turnaround time is of prime importance. With this objective, I am submitting a simple method, or formula, for calculating turnaround time for use in railway administration, subject to correction by my fellow workers.

Basic Factors in the Simple Method and the Formula in Which They Are Used

We know that turnaround time is expressed in terms of the number of days and decimal fractions thereof, and that it is made up of three components, namely, travel time, switching time, and stopping time. The formula to be used in our calculations is as follows:

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(1) Turnaround Time equals 1/24 (Travel Time plus Switching Time plus Stopping Time)

Using abbreviations: TRT = 1/24 (TRVT + SWT + STPT)

This basic formula, (1), may be developed and reduced by eight successive steps as follows:

(2) $$TRT = 1/24 \left(\frac{(1 + PCE) \times TRD}{TRVS} + \frac{(1 + PCE) \times TRD}{SWD} \times SWT + WR \times STPT \right) =$$

(3) $$= 1/24 \left(\frac{(DCL + (DCL \times PCE)) \div DWL}{TRVS} + \frac{(DCL + (DCL \times PCE)) \div DWL}{TKM \div NCSW} + \frac{Total\ SWT}{NCSW} + \frac{CLD + CUN}{DWL} \times \frac{Total\ STPT}{CLD + CUN} \right) =$$

(4) $$= 1/24 \left(\frac{(DCL + DEC) \div DWL}{TRVS} + \frac{(DCL + DEC) \div DWL}{TKM \div NCSW} \times \frac{Total\ SWT}{NCSW} + \frac{Total\ STPT}{DWL} \right) =$$

(5) $$= 1/24 \left(\frac{TKM \div DWL}{TRVS} + \frac{TKM}{DWL} \times \frac{NCSW}{TKM} \times \frac{Total\ SWT}{NCSW} + \frac{Total\ STPT}{DWL} \right) =$$

(6) $$= 1/24 \left(\frac{TKM}{DWL} \times \frac{1}{TRVS} + \frac{Total\ SWT}{DWL} + \frac{Total\ STPT}{DWL} \right) =$$

(7) $$= 1/24 \left(\frac{TKM \div TRVS}{DWL} + \frac{Total\ SWT}{DWL} + \frac{Total\ STPT}{DWL} \right) =$$

(8) $$= 1/24 \left(\frac{TKM \div TRVS + Total\ SWT + Total\ STPT}{DWL} \right)$$

NOTE: 1. Total kilometrage divided by travel speed equals total travel time.

2. Total switching time consists of the sum of time spent in switching operations of all the cars switched.

3. Total stopping time consists of the sum of the time spent by all cars in the terminal stations for loading and unloading operations.

If no error has been made in these calculations, we may now proceed to show that this simplified form of the formula, (8), is correct and practicable.

Application of Formula

To show the correctness of the formula, and to point out the relationship between the various factors, suppose that a certain bureau for a certain month reported the following figures which we will use as data.

Number of cars loaded, 7,042; daily average [31 days], 227 cars.

Number of loaded cars received from neighboring bureaus, 3,339; average 108.

Number of loaded cars handled, [DWL], 10,381; daily average, 335 cars.

Number of cars unloaded, 7,966; daily average 257.

Total monthly kilometrage, 3,115,855; daily average total kilometrage, 100,511 kilometers.

Loaded car kilometrage, 2,573,434; daily average, 83,014 kilometers.

Number of cars switched, 18,765; daily average, 605 cars.

Total switching time, 39,680 hours; daily average, 1,280 hours.

Each car average switching time, 2.1 hours.

Number of car loadings and unloadings, 15,008; daily average, 484 operations.

Total stopping time, 105,228 hours; daily average, 4,846 hours.

One loading or unloading operation, average 10 hours.

Travel speed of freight trains, 17.9 kilometers per hour.

Percentage of empty cars in trains, 21 percent.

Average turnaround distance of loaded cars, 248 kilometers.

Having the above data, the first step is to put them in the general formula:

$$(2)\quad TRT = 1/24 \left(\frac{(1+21\%) \times 248}{17.9} + \frac{(1+21\%) \times 248}{100{,}511 \div 605} \times 2.1 + \frac{227+257}{335} \times 10 \right) =$$

$$= 1/24 \left(16.76 + 3.79 + 14.45 \right) = 1.46 \text{ days}$$

If the simple formula is used, only the most basic figures are required to compute the turnaround time, and the result will be the same. It is much quicker and just as satisfactory. It is not necessary to use a lot of complex data. All that is necessary is to ascertain the total kilometrage, total switching time, total stopping time, and the daily work load. The formula and result is as follows:

$$(8)\quad TRT = 1/24 \left(\frac{TKM \div TRVS + \text{Total}\quad SWT + \text{Total STPT}}{DWL} \right) =$$

$$= 1/24 \left(\frac{3{,}115{,}855 \div 17.9 + 39{,}680 + 150{,}228}{10{,}381} \right) = 1.46 \text{ days}$$

Comparing the values of the components in the long formula (2) with the corresponding components in the simple formula (8), it is seen that the travel times differ by only 0.01 hours (16.77 - 16.76); the switching times differ by only 0.03 hours (3.82 - 3.79); and the stopping time by only 0.02 hours (14.47 - 14.45). /These differences are cumulative, and amount to 3.6 minutes, or 0.0025 of a day./ Since there is practically no difference in the turnaround time, it is seen that the simple formula can be used to yield reliable figures for turnaround time.

Car-Count Formula and the Time-Count Formula

By the Car-Count Formula is meant:

$$(9)\quad TRT = \frac{\text{Total number of cars in operation /COP/}}{\text{Daily average number of loaded cars handled /DWL/}}$$

This is regarded as giving the "true" turnaround time.

By the Time-Count Formula is meant:

(1) TRT = 1/24 (Travel Time + Switching Time + Stopping Time)

This is regarded as the basic formula for turnaround time.

At first, it may seem that these two formulas have no relation to each other. Actually they amount to the same thing; it is a case of six of one and half a dozen of the other. [Considerable space is devoted in the text to explain the relationship between these two formulas. This reasoning is not reproduced here.]

Since the two formulas are equivalent to the same thing, they may be used together to calculate the number of cars in operation. Thus:

$$\frac{COP}{DWL} = TRT = 1/24 \left(\frac{TKM \div TRVS + SWT + STPT}{DWL}\right)$$

$$COP = 1/24 \left(\frac{3,115,855}{17.9} + 39,680 + 150,228\right) =$$

$$= 15,165.8 \text{ cars}$$

While the number of cars in operation as determined by computation may not be exactly equal to the actual number, the difference should be extremely small. Often the discrepancy may be due to incompleteness or inaccuracy in the recording or reporting of the data. If the computed value of TRT differs unreasonably from the "true" figure, it must be concluded that there is some error in the data or in the calculations. Therefore, it is essential that the basic data should be carefully collected and that all calculations should be verified at the time they are made; otherwise, the results of the calculations will be of no value.

Determination of Satisfactory Use of Cars

The Ministry of Railways has instituted a system of conferences by long-distance telephone. In discussing the use of cars, they talk only about the factors that have a bearing on turnaround time. Each railway bureau has a similar telephonic conference every 10 days in which all the subbureaus participate. In these conferences, figures are reported for the preceding 10-day period concerning number of cars loaded, tonnage dispatched, number of cars in operation, nature of cargo loaded, total turnaround distance, switching time per car, stopping time per car, train travel speed, etc. The planned figures and the actual figures are compared, and the percentage of accomplishment in each case is computed. On the basis of the percentage of accomplishment the excellence of the operations of subbureaus and bureaus is judged.

Without reliable data it is impossible to formulate practicable plans for the future. Furthermore, there are differences in the trustworthiness of the data supplied by the various subbureaus and bureaus, hence it is difficult to reach fair judgments concerning the reported accomplishments. For these reasons, I suggest that among the items to be reported the turnaround time, calculated by both the Car-Count and the Time-Count Formulas, should be required, and that the former be taken as the true figure with which the latter is compared. In this way, the relative degree of reliability of the statistical data and calculations that are reported by the respective units may be judged.

Let us illustrate how to evaluate the accuracy and reliability of the periodic reports. The figures in the following table are supposedly reported for a certain month by five different bureaus.

Bureau	No of Cars in Operation	No of Loaded Cars Handled	Total Switching Time	Total Stopping Time	Total Kilometrage	Av Travel Speed of Train	Total Travel Time
A	62,766.0	23,603.0	151,051.5	812,113	10,263,340	18.2	563,919.0
B	71,820.0	24,643.0	138,113.5	830,387	11,127,112	17.9	621,626.4
C	79,540.0	29,627.0	179,121.5	939,501	12,974,551.5	17.6	737,190.4
D	73,800.0	27,621.0	196,277.5	759,391	12,558,102	17.2	730,122.2
E	79,716.0	16,044.0	54,394.0	445,343	6,970,809	11.73	594,271.9

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Calculations of the turnaround time by both methods show the following discrepancies.

Bureau A: By the Car-Count Formula:

$$\frac{62,766}{23,603} = 2.66 \text{ days}$$

By the Time-Count Formula:

$$1/24 \left(\frac{10,263,340 \div 18.2 + 151,051.5 + 812,113}{23,603} \right) = 2.70 \text{ days}$$

Discrepancy:

$$\left(1.0 - \frac{2.70}{2.66}\right) \times 100 = 1.5 \text{ percent}$$

Similarly, the discrepancies for the other bureaus are found to be: Bureau B, less by 19.2 percent; Bureau C, less by 2.6 percent; Bureau D, less by 0.8 percent [sic]; Bureau E, less by 42.9 percent.

The discrepancies vary widely; this indicates that the respective degrees of reliability also vary. The reported accomplishments of each bureau therefore ought to be discounted to some extent in proportion to the percentage of discrepancy indicated above. [The author here suggests a graduated scale for discounting the degrees of accomplishment claimed in the ratio of the percentages of discrepancy. The editor of the Chinese periodical inserted a note to the effect that he considers the proposed scale too lenient.]

A method of rating the performance and degree of accuracy and reliability of railroad reporting is felt to be desirable and necessary. Such a rating would be an incentive for greater interest, care, and accuracy on the part of the working forces in the offices and on the lines.

Reason for Inaccurate Data

Inaccurate data are the result of either ignorance or carelessness on the part of the workers concerning the operations and significance of the data involved; or falsification in the reported data. If the former is the case, it is a matter for instruction, training, and encouragement; if the latter, the only proper action is to discharge the guilty persons.

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